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Bulletin of the

Society for the Promotion of Engineering Education

VOL. X LANCASTER, PA., NOVEMBER, 1919 NO. 3

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THE PURPOSE OF ENGINEERING SCHOOLS.

BY FRANK J. GOODNOW,

The Johns Hopkins University.

It gives me great pleasure to avail myself of the privilege which is mine as representing the Johns Hopkins University to welcome the members of the Society for the Promotion of

Engineering Education at their meeting on this occasion. The university esteems it an honor that you have accepted our invitation to carry on your deliberations within our halls. Our feeling of gratification is due to two considerations. In the first place we feel pleased that you are here. In the second place we congratulate ourselves that, although we have perhaps the youngest engineering school in the country, you have been willing to welcome this infant, so to speak, among the ranks of mature men. We feel sure that we shall profit greatly as we listen to the words which you will utter, based as they will be, on your long experience in the field which we all are cultivating.

I feel, however, that my words of welcome should be accompanied by an apology, perhaps, I should say apologies. For as I see it two apologies are due. One, an institutional apology. The other, a personal apology.

I have referred to the youth of our engineering school. Now youth, whatever may be the advantages, which are its incident, is subject to certain disadvantages. Our institutional youthfulness consists not merely in the recent establishment of our school but as well in the fact that the university, of which the school is a part, has been located at its present site for only a very short time. We have had neither the time nor unfortunately the money necessary to put our physical environment into a condition which permits us to offer to you the kind of hospitality which you deserve. We have no dormitories in which we can give you accommodation nor a commons in which the material wants of the inner man can be satisfied. We must perforce ask you to make a somewhat long journey from your hotels to Homewood, and to pick up a hasty lunch in the midst of the machinery with which your work days are perhaps too familiar.

When I think of what we can offer you I am somewhat amazed at our audacity in inviting you to hold your meeting here. I fear indeed that had you known our conditions you would have hesitated somewhat before consenting to come.

But we are glad to have you with us and I hope that your meeting will be successful, profitable, and interesting.

I have said I owed you a personal as well as an institutional apology. That apology is due for what I am going to say apart from these few words of welcome. It has been my fate to be president of an institution which pays comparatively little attention to those branches of study with which my past work has made me familiar. A lawyer I have been for the past five years, connected with an institution which has no law school. With little, if any knowledge, of science or the mechanical arts I have been obliged to concern myself with questions to whose solution I have been able to contribute but little. You can well imagine that during the past five years I have had to submit myself to a process of education.

So when it becomes my privilege to address the Society for the Promotion of Engineering Education, and when I realize that I am venturing to say something on the subject which specially concerns that society I am reminded of a story I heard the other day of a university president who had been long in the harness and who knew pretty well what was to be expected at such functions as university presidential inaugurations. He was in a train en route for one of these ceremonies when a friend saw him and asked him where he was going. His reply was "Oh, I am going to hear some first thoughts on education." When I recall that story I am conscious of the fact that I am taking perhaps an unjustifiable advantage of you in asking you to listen to some first thoughts on engineering education.

My only excuse for making this demand of you is that largely because of our recent experiences educational waters generally are stirring and I feel sure that the waters of engineering education are no exception to the rule.

Some of the first thoughts on this subject which have come to me, really a layman, are in the nature of queries rather than conclusions.

The most important as it seems to me is the query:

What is the purpose of an engineering school? Perhaps

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the query should not be framed this way. For it may well be that there is no such thing or should be no such thing as a typical engineering school. Perhaps there are and should be different types of these schools. If this is the case, then I suppose the query should be, what is the purpose of the particular school with which we happen to be connected? This query it seems to me we must answer before we can reach any really valuable conclusions as to the character of the engineering education which we should endeavor to provide.

As I have come to see it, engineering schools in general or any particular school may have one of three purposes. Perhaps, while any particular school may emphasize one of these purposes it may have the other purposes as well in mind.

Now these purposes as they outline themselves to one who comes without any experience and with very little knowledge to consider these problems are: (1) General education with emphasis laid on scientific subjects; (2) professional training; and (3) engineering research.

Some schools which I imagine may be classed as engineering schools started as scientific schools, *i.e.*, schools in which it was sought to give a general education through the study of subjects scientific rather than literary in character. Many schools which when organized were schools for the cultivation of mechanic arts have become schools devoted to general education with emphasis laid on the sciences and giving little if any attention to classical studies. There is further, little doubt that many of the graduates of engineering schools do not as a matter of fact make engineering in any of its branches their profession, while it is also true, I believe, that some eminent engineers never had an academic engineering training but went from a so-called literary college into the practical work of the engineering profession.

Now, if the purpose of engineering education, or perhaps I should say if the purpose of an engineering school is to give its students a general education which will be of benefit to them in other than the clearly professional ranks of life the problems which present themselves are very similar to those

presented in the ordinary college. They are not exclusively intellectual but are as well moral problems. What must be sought is in some way to foster the building up of character, the cultivation of industry, particularly intellectual honesty, the capacity to evaluate correctly the things which life presents and the ability to make a profitable use of one's leisure time. If the scheme is to be successful these qualities must be developed in addition to the acquisition of any particular facility or any particular kind of information.

If, however, the primary purpose of the school is professional training I imagine few of us would be willing to say that a by-product, at least, of the school should not consist of the qualities which I have mentioned. I have used the word by-product because I feel that no set of subjects of instruction can claim a monopoly in the production of these qualities. Some of them will be the result of the community life which the students live. Some will be due to the personal influence of the instructor. For few, if any, will the subjects studied be solely responsible.

But assuming that the qualities which should be the result of all education are secured, a scheme of education which emphasizes professional training as its principal purpose, must seek for something more. What that something more should be is a question which I hesitate to attempt to answer. I am afraid my first thoughts are not sufficiently definite or not sufficiently based on experience to have any great value. I can only make a few hesitating suggestions based on experience in other fields. There is always great danger in any line of work that instruction in it becomes entirely academic. The instructor is always apt, particularly if his life is encompassed by the barriers of institutional environment, to get out of touch with actual life. He comes to live in a world of his own and of his immediate fellows which is quite different from the extra institutional world. In some lines of work such an attitude of mind may not be accompanied by serious disadvantages but a professional school whose instructors are of this character tends to become too theoretical. Its instruc-

tion easily becomes too didactic. Its learning becomes almost purely book learning. Its graduates find when they enter real life that they have much both to learn and unlearn. I imagine the history of engineering education will show not a few instances of this tendency towards the academic and away from the actual. Certainly this has been true of many of our agricultural colleges. I remember one case decided by one of our state courts which is illustrative. An action had been brought to take away a charter from an agricultural college because of the fact that it was using for classical instruction money given for the teaching of agriculture. The court refused—courts are always reluctant to forfeit charters—to take away the charter alleging as the reason for its action that a knowledge of Latin and Greek would assist the would-be agriculturalist to understand agricultural terms.

The same problem confronting engineering schools which emphasize professional training as their primary purposes, has also confronted the professional schools of law and medicine. Thirty years ago instruction in these schools was almost entirely didactic. In the law schools the student studied text-books and attended formal lectures. He seldom read a case. In medicine conditions were almost the same. The student read about typhoid fever and pneumonia in a book or heard them described in a lecture. He seldom, if ever, saw in his course of study an actual case of a person afflicted with these diseases. He certainly never participated in the care of patients. This has in large measure been changed. Law students read and discuss actual reported cases as a part of their regular course of instruction. Medical students receive what is called bedside instruction in hospitals attached to the schools they attend.

The problem of the professional engineering school must be solved in somewhat the same way. Laboratories may help but they will not be sufficient. For laboratory equipment soon gets out of date and with the resources at the command of most schools may not be scrapped and replaced by something new. The engineering schools will have to devise some

contact with the outside world which will make their instruction real and prevent it from becoming merely academic. But that contact must be such that neither the instructor nor the student gives up more of his time to purely routine operations and processes than is necessary to acquaint him with the conditions of the world he is to enter.

Finally, even in a school which emphasizes professional training something must be done for the student which will help him in his life outside of his profession. For he is a man and a citizen as well as an engineer. As a man he must live a life which has many other than professional contacts. He will be in a world which has other than professional interests. To get the greatest profit from that world and to lead a life which is most worth while he must some time during the period of his education lay the basis for the cultivation of tastes which will enable him to enjoy non-professional things. As a citizen he must participate in the solution of problems which democracies must solve. It is true that the cobbler must stick to his last but when cobblers are called as they are in popular governments to take a share in the determination of policies they must in some way be assisted to reach right conclusions. What is true of cobblers is even more true of engineers. For engineering may be regarded as a learned profession and engineers are educated men, who may properly be called upon to share the leadership which is so necessary to wise political action. I heard the other day of a student in the Students' Army Training Corps in one of our leading universities who was asked in an examination the name of the people who inhabitated Hungary. His answer was the "McGuires." While that answer revealed the fact that the man had a basis of historical and political knowledge, yet that knowledge was so limited and imperfect that it might lead to the conclusion that he had mistaken Hibernia for Hungary.

I would not be understood as asking that the engineering student should be expected to acquire an extensive historical knowledge during his undergraduate course. With the de-

mands made upon him by his strictly professional subjects such an expectation would be doomed to disappointment. But after all there is no reason why engineers should not be reasonably cultivated men. And for the average man the foundation for such cultivation as he is successful in acquiring must be laid in his college course.

One of the difficulties which will be encountered by those who try to lay this foundation is the reluctance which the average engineering student has to devote himself to these non-professional courses. He regards them both as useless and uninteresting. Perhaps a large measure of blame for his attitude must be laid on his instructors. Perhaps if a greater attempt were made to make these courses attractive even at the peril of having them regarded by the student as "cinch" courses greater success would attend our endeavors to coax the engineering student to consider of value the non-professional work which in his own interest he should be required to undertake.

The two problems which would appear to be as yet unsolved in the schools which emphasize professional training are thus the contact with the outside world of engineering and the cultivation of the man and citizen as well as the engineer.

The third purpose which engineering schools in general or some engineering school in particular may emphasize is engineering research. This purpose is probably the most difficult of realization. Research in pure science may without great difficulty be carried on within academic walls. It, of course, involves the expenditure of large sums of money needed for the equipment of laboratories and for the staff to which the investigation of problems is intrusted, but experience has shown that carrying on such research is not beyond the powers of educational institutions. When, however, we come to the applications of science conditions along many lines are quite different. The laboratory methods which suffice for pure scientific research are often ill adapted for the work which must be done. For the purpose of much engineering research is not so much the ascertainment of scientific truth as it is the

determination of the commercial practicability of particular methods of quantity production. This purpose can hardly be realized in many cases in any laboratory which a university may be expected to provide. Engineering research must in many cases, to be successfully prosecuted, be carried on in the factory and in the mill.

There are, however, unquestionably many problems the solution of which can be begun in an engineering laboratory. There are probably some the solution of which may be completed there. So far as this is true it is very desirable that an engineering school should, if possible, devote some of its attention to their solution. For the student who thus learns to solve problems not only acquires knowledge about his profession but at the same time cultivates a mental attitude the possession of which will probably be of greater value to him than the mere acquisition of knowledge. Work of this character is even more valuable to the instructor than to the student. Successful accomplishment in this direction at the same time stimulates his imagination and makes him a more inspiring teacher. No one who has devoted many years to teaching can fail to notice the deadening influence upon his work of a persistent and continuous attention to what is known unaccompanied by some striving on his part to apply what he knows to the discovery of something that is unknown.

It may well be, therefore, that the most successful engineering schools will be ones which endeavor on the one hand to use the subjects which they are called upon to teach as subjects from which some measure of general education can be obtained and on the other to give a reasonably adequate professional training with which will be combined some attention to research. But it can hardly be expected that any school can hope successfully to do much more than to lay the foundations upon which the student must subsequently build. No engineering school, any more than a college, can expect its students to acquire all that is comprised in a general education. No engineering school, even if it devoted itself exclusively to professional training, could hope to turn out its

graduates finished engineers. Nor could it if it gave all its time to engineering research hope to solve all the problems which arise in industry.

So it seems to me that the problem at the basis of engineering education is essentially the one lying at the foundation of all education, which can be carried on in an institution more or less academic in character. This is the combination of fundamentals, a reasonable breadth of view and the cultivation of the capacity to solve the new questions which are continuously presenting themselves in every line of work. Such are some of the first thoughts on engineering education which one not a member of the guild ventures to present for your consideration today.

INDUSTRIAL RESEARCH—ITS FUNCTION AND ADMINISTRATION.*

R. E. CARPENTER,

Manager of Lynite Laboratories of the Aluminum Castings Company, Cleveland, O.

While a great deal has been said of late in various technical publications regarding research work and the organization of industrial research laboratories, I believe there is still opportunity for the advancement of the idea, since not only does the manufacturer or proprietor shy at the word "research," but he is more or less aided and abetted in this tendency by a certain percentage of the engineering fraternity. I believe certain mechanical engineers are a bit too prone to consider their textbooks the last word and to place too little value upon advanced scientific developments which are being made from day to day not only in our college laboratories but in the industrial laboratories that are becoming more and more general throughout the manufacturing world. The fact is that a large amount of valuable research work which is being carried on today is of an absolutely non-sensational order and in many cases, being of a confidential character, it therefore does not get into the limelight of publicity through the technical literature. The fact that such data are not available in the literature until it has served to advantage those producing it, I believe to be one of the best arguments in favor of industrial research work. Each individual concern must carry along its own scientific developments if it is to stay abreast with the times. Many important scientific developments are first brought to light in the form of a finished product ready for the market, perhaps a considerable time after the scientific

* Read at the Mid-West Sections Meeting, A.S.M.E., Indianapolis, Md., October 25, 1919.

phases of the work have been written into history, which history, however, is for the particular benefit of the concern financing the work. Some of the most profitable and beneficial lines of research have to do with the stopping of the leaks that are bound to occur in concerns whose business is expanding rapidly, particularly those utilizing or producing raw products.

Writers on the subject of industrial research have used as an example the development of the tungsten filament, which happens to be one of the sensational products of research, until this illustration is practically worn threadbare. However, the most pessimistic cannot but admit that the old saying, "Where there is so much smoke there must be some fire," holds true with respect to the awakened interest now evidenced in industrial research throughout the country. In my remarks on this subject, I shall endeavor to deal more particularly with some of the fundamental functions of research to industry and the principles involved in the administration of research affairs and bring out as clearly as possible those phases of the work that are analogous to any well-organized industrial activity. The coördination of research and development departments with those of production and sales is as important as the coördination of the actual activities of the research and development organization itself.

In spite of the fact that the word "research" is one with which the industrial world is becoming more and more familiar, I believe in the minds of many manufacturers it is still shrouded with considerable mystery and hazy misconception. When the word is spoken, some of us have a mental picture of the proverbial absentminded college professor surrounded by a disorderly array of miscellaneous apparatus, delving into abstruse phases of some given art or science in the hope that he may hit upon some new law, force or element with which to startle the world, but we do not associate him as a benefactor of our everyday life. Let us forget this picture and define the word "research" in a more up-to-date manner.

INDUSTRIAL RESEARCH.

The dictionary says "research is a systematic investigation of some phenomenon or series of phenomena by the experimental method to discover facts or coördinate them as laws." To tie this definition down to industry a bit more definitely, I would say that the object of industrial research is the establishment of improved standards by acquiring and compiling technical data of which fundamental facts are the basis.

The necessity of acquiring reliable technical information and facts concerning any given art is today coincident with the development of any large manufacturing establishment, provided such establishment is laying broad plans for the future.

A great deal of valuable work has been done in past years under the guise of engineering development which might basically be called research work, but the term was not at that time as popular as it has become today. I refer particularly to the utilization of by-products which has been carried out to a remarkable extent by various large industries throughout the country.

Dr. Meese has quite properly stated that the smaller the concern the more urgent the necessity for research work. There is hardly a concern today dealing with manufacturing processes that cannot afford to spend a certain portion of its income in studying the purely scientific phases of its product. Industrial development and advancement must be based upon standards and the establishment and maintenance of these standards is of vital importance to the growing concern.

The numerous process troubles which are encountered in the manufacture of practically everything we use today are the first manifestations of the necessity of these standards and as a business becomes more complex, these troubles become more and more numerous and the necessity for analyzing them and ascertaining the facts back of them necessitates the application to the problem of minds trained in the various sciences involved. Pure scientific research may be shared by both the college and industrial laboratories, but applied sci-

ence must be fostered by industry alone. It is as important to know what not to do as to know what to do, as a great deal of time and money is often spent in doing the wrong thing over and over in various ways before the right way is found, more or less by accident.

As an example of one of these works problems that caused one of our largest industries a great deal of trouble for many years, I would cite the instance of the effect of changing humidity on the spinning and weaving of cotton. About twenty years ago this problem was studied by ventilating engineers and a method of atomizing moisture into the atmosphere of the spinning and weaving rooms of cotton mills was developed so that a close control of the humidity could be maintained and the tendency of the ends to break because the weather changed over night from humid to dry or to slacken up and necessitate considerable readjustment if weather conditions were the reverse, was obviated.

While the need of research in industry is first felt by the necessity of applying science to solving fundamental problems of production, the research department, if properly manned and backed up does not long assume the rôle of the doctor prescribing to the ailments of business but by reason of the knowledge and experience thus gained soon assumes the rôle of pilot laying the course of the ship of industry through safe channels along the rugged shore of experiment and development to the ports of profit and success.

In the administration of industrial research affairs, an important phase is the coördination of the different types of minds one encounters in a manufacturing establishment, all of which can further or retard the work, depending upon their attitude toward the proposition. Another and very important phase is the selection of tasks or problems. Usually these will be presented in large numbers and will have to be weeded out by preliminary consideration. I strongly recommend the clear definition of each general problem and its details; the very definite recording of its object and the estab-

lishment of a budget system requiring separate appropriations for each problem which may have to be increased from time to time if the problem takes on a more elaborate character of investigation than at first anticipated.

Space, facilities, and apparatus are never ample from the viewpoint of the research worker, but these should nevertheless be provided without stint if good and quick work is to be expected. The mistake is often made of hiring a good man and limiting his usefulness by inadequate facilities with which to perform his task.

I cannot entirely agree with the fifth conclusion in Dr. Frank B. Jewett's paper read before the Royal Canadian Institute at Toronto, September 8, 1918, and recently quoted in *Mechanical Engineering,* in which he states that, "Whatever the scheme finally adopted to provide for an expansion in the domain of fundamental research and the development of competent industrial workers, care must be taken to insure that pressure from the industries will never be so great as to withdraw those men who can render the greatest service by continuing as investigators in the field of pure research and the training of younger men."

He goes on to say that "Such a course would be suicidal if long continued and I mention the point because of the fact that my experience indicates a considerable tendency on the part of industries which have benefited from industrial research to endeavor to attract into their service the best of the university research men."

Dr. Jewett's conclusions may in part be true, but I certainly feel that such conclusions may be properly considered to include simply men of strong individualistic tendencies who would with considerable difficulty conform to the requirements of organization work or who, by reason of their own desires, would prefer the sanctity of the university laboratory to the opportunities presented in well organized and financed industrial research work along some specific line.

On the other hand, I feel that it is entirely legitimate and

necessary for industrial institutions to search out men of genius and promise, even though they may be filling important places on the faculties of educational institutions and give them the opportunity to further broaden their horizon in assisting to organize and conduct industrial research where they have the opportunity to take the young college graduate crammed with theoretical textbook knowledge and assist in the great work of educating him in the application of these theories to the everyday problems of some specific industry.

We must not overlook this very definite need for breadth of vision and mature judgment in the training of the rank and file of industrial research workers and I maintain that our educational institutions must share such talent with the industries in order to carry this work to its end at maximum efficiency and speed.

Let us dwell for a moment on the industrial research organization from a personnel standpoint. Let us assume, for example, that a certain industrial establishment already has an engineering department and is producing a product that requires mechanical engineering talent, not only in its design but in its production. Let us also assume that the pressure of competition as well as the necessity for broadening and extending its field of usefulness has so impressed the executive head of the business that he feels the necessity for a more scientific understanding of the materials and processes that enter into his product than his present organization can supply, which understanding in turn may assist in a still broader application of his product to the market as well as the possible greater utilization of by-products. He therefore decides to organize a research department capable of covering all three of these phases of his business in a thorough and scientific manner. His first step should be to select from his own organization, if possible, some one in complete sympathy with the ideas and of sufficient breadth of vision and experience to appreciate the point of view of the scientist as well as the engineer; with some knowledge of his business problems and

a general knowledge of business affairs. It is vitally important in the early days of a research department of any business that someone who has a keen appreciation of the point of view of the board of directors, and the production and engineering department as well as that of the scientific worker should act as the intermediary between these various divisions of the organization, as any one endeavoring to introduce research into an established and going business will find a tremendous lack of sympathy on the part of the production organization for the mental attitude of the research worker. Respect for and confidence in the new department can only be built up by the tactful education of all factions which must positively be properly coördinated if the work is to be a success.

This is a difficult position to fill, but it is vitally important. In a small concern the president or general manager is the logical person to function in this position, but in a large concern of extended affairs a separate individual is necessary and should be responsible directly to the president. This individual must, also, have sales ability, since on the one hand he must continually sell the proposition of research to the production organization and on the other hand sell the needs of production and sales to the research organization. He must furthermore assume responsibility for administering all of the routine affairs of the department so as to relieve the scientific director himself of all annoying details so that his whole thought and time can be devoted to the direction of the scientific phases of the work. In some of the large industrial laboratories that have been established for a number of years we find the scientific director carrying this function on his own shoulders, but it is usually found that such directors have had some considerable experience in and knowledge of general manufacturing processes in the specific art involved and have had the sympathetic coöperation of some principal of influence in the organization to help them over their early trials. It is, however, extremely difficult to find the combination of

qualification necessary to function in both capacities in one man.

We will now consider the scientific director himself. He should be a man, preferably of some standing and experience in the particular science most involved in the company's product, well balanced in his ideas, strong of character and yet not individualistic with ability and experience as an educator. He must necessarily embody a keen understanding of human nature, and be as young a man as can be found that will answer the requirements, as very often several years are required for him to gain a thorough knowledge of the practical traditions of the particular product which he is to consider from a scientific standpoint. Such a man should ultimately become a powerful factor in stabilizing and building the business. The director's first duty will be to carefully study the company's product and production problems. He must qualify himself as an authority on all of the technical phases of the business and while he himself may do but very little of the scientific work, he must be able to direct same and judge results. His second task is the selection of his scientific staff and his ability to do this well will in a large measure spell his success and that of the department. A specialist in each branch of science involved in the company's business should be secured and he should be allowed in turn to secure his assistants.

Supporting this scientific staff should be provided various service features, such as a staff for library work, the compiling of bibliographies and the abstracting of articles from technical publications. A close liaison should be maintained with sales, production and patent departments by one or more individuals with scientific, engineering, or practical experience as the case may require. I believe that it is often highly desirable to mix with scientific men a number of engineers and practical specialists, particularly if the work of the Research Department combines any phase of experimental development.

The most important phase of the first two years work of

an industrial research department is the development of men. Therefore, select young men with potentialities whose training and enthusiasm will provide a ground work for the development of concerted team work rather than brilliant individual attainment.

To vitalize the immediate future of industrial research, we, first individually, and second collectively as a great engineering society, have a real work to perform which might well be considered a duty. We passed some time since from that period of industrial development in this country marked by the slaughter of natural resources which lay in such abundance that huge industries were built up without any considerable regard for the economic and complete utilization of nature's stocks. For several years far-sighted men have been preaching the doctrine of conservation of natural resources. One phase of such conversation is the more complete utilization of what we are obliged to consume. This means scientific research, not only in the iron and steel industry, the paper industry, the packing industry, the electrical industry, all of which have well-advanced research departments at the present time, which incidentally, is one of the reasons for their size and impregnable position, but scientific research in every industrial activity of the nation. Every last thread of our national industrial fabric must necessarily pass under the microscope of science if it expects to survive. Every ramification of our business structure must do its share of writing the textbooks of the future. That is all that research is—simply using the scientific knowledge of today to write the science for tomorrow, but since this must needs be checked and verified, as we go along, we use the industries upon which depend our very existence as the vehicle for its propagation.

The introduction of science into industry serves a double purpose. By reducing cost and at the same time improving product, it automatically raises the whole standard of manufacturing products, thereby stimulating national competition which will, in turn, help us to stem the tide of international

competition. The necessity of intensive utilization of space and resources has awakened Europe to the importance of research until it is far ahead of us today in this respect. We must study this situation at first and profiting by what has thus far been accomplished in Europe, so organize our industrial research that we may assume an offensive rather than a defensive position in the markets of the world. If we can but convince one or more prominent concerns in each industry that the application of pure and applied scientific research to their business will be beneficial and get them to organize properly balanced departments for this purpose, their competitors will be obliged to follow suit in a short space of time if they expect to survive.

We have two distinct types of research laboratories to look to for precedent and ideas at the present time,—institutional and industrial. The first has a great work to perform in the early development of research workers. The second, which might be termed the graduate school, has also an important function in providing the young research worker turned out by the institutional laboratory with the facilities and character of problems that will enable him to apply his theoretical training to definite and beneficial ends that are vital to the very existence of our industrial life.

SOME REMARKS ON COÖPERATIVE METHOD OF ENGINEERING EDUCATION.

BY V. KARAPETOFF.

It is true that a student in engineering gets more out of theoretical subjects if he has had some previous practical experience in the same branch of work. The theory appears more tangible to him and he has more judgment as to the relative importance of various factors. It is also true that a student gets more out of his shop or testing experience when his first steps are guided by a competent instructor. Practical experience during the college course also has some other advantages; for example, it is not so humiliating to be in a subordinate position or ask foolish questions before one gets his degree. Again, those unfit for practical work can early find this out, and those particularly fit for a certain kind of work early establish valuable connections with suitable firms.

Shop experience for students is also good for colleges themselves, because it helps to keep them in touch with up-to-date practice and keeps the teachers on the qui vive for all kinds of unexpected practical questions. It is also good for the shops to have a sprinkling of college students among their workers and foremen.

But in spite of all these advantages of coöperative systems, the big question is, can such a system be actually carried out efficiently, without detriment to the academic instruction? In colleges situated near industrial centers the schedule calls for a change from school to shop and back every few weeks, but in a university like Cornell remote from large factories, each shop period must be at least one term long.

The shop conditions are such that men have to have long hours and much monotonous routine work. If left alone they chafe because of alleged waste of time, and if they have classes

in the evening and have to write reports they get tired out and lose all interest in either shop or theory.

If the intention is to still limit the whole course to four years, then this can be done only to the detriment of theory and of scholastic academic atmosphere; if the whole course be proportionately lengthened then there would be a great temptation to go to schools which have no coöperative system and offer the same degree in four years.

The present cry is to elevate the engineering profession, to make the engineers broader in their economic and political views and also to give them a more thorough scientific training. There is no question that a shop experience would be a useful factor in both respects, provided that the unsystematized observations made there are properly interpreted and generalized by broadminded experts. Otherwise, the shops would tend to narrow down the student's horizon, by emphasizing firmly established things rather than imagination and search for new relationships. It is quite possible that with properly organized shops and laboratories in the college itself the good sides of shop experience could be preserved without their disadvantages.

Experimental psychology and especially late tests on students and on army soldiers show tremendous differences among men who have hitherto been assumed to be of about the same mental caliber. Therefore, fixed curricula and the prescribed quantity of work seem now more absurd than ever, because with two men the same amount of work does not correspond even approximately to the same mental stimuli and response. From this point of view it is wrong to advocate shop experience or to be against it for all the students. Some men would undoubtedly become better and more useful engineers with the coöperative system, while others would be simply dulled by it. For these "others" the place of the shop should be taken by extra chemistry, economics, differential equations, psychology, research, athletics, art, or whatnot, according to their mental, volitional and emotional type.

In colleges situated near industrial centers the coöperative system can be carried on by changing from shop to school every week or two. No definite conclusion can be gained at the present time as to the absolute success of this system as carried on in two or three well-known universities, notably in Cincinnati and in Pittsburgh. It is quite possible that such a system can be quite successful with a proper organization, and with teachers who believe in this system and who put inspiration in it. It probably works well with some students and others probably hate it heartily.

It would seem that changing at frequent intervals from one form of activity to another should involve considerable waste of time in acceleration and retardation. Even with ordinary regular recitations in a subject say twice a week the students seem to forget a great deal between two recitations.

Summer vacation would seem to be the proper and natural time for practical experience, or a whole year taken off before the senior year. It would not be too much of a hardship to require each student to spend the whole summer before his senior year in good hard practical work and to write a report on it as part of the requirements for graduation. This was a requirement in the C. E. College in Petrograd from which the writer was graduated. Additional inducements might be given students for spending their other vacations in practical work, provided they present suitable reports giving their experiences and an analysis of the same. Even academic credit could be given for such work under properly safeguarded conditions.

The problem of shop or no shop during the college course is not a burning or important one at the present time. The paramount problem is that of adaptation of education to the individual. Recent psychological studies show such tremendous differences in individual abilities and in the kind of stimuli necessary to inspire men to do their best that it seems like a crime and a folly to put thousands of young men each year through the same standardized grind. The next prob-

lem is to test your students at frequent intervals as to the state of their soul (not the amount of actual information) and to prescribe the necessary treatment. So a skilled photographer watches his plate during the process of development and adds this or that ingredient to his solution according to the state of the emulsion and the character of the details that are showing. We teachers, on the other hand, put hundreds of plates in a big tank and turn the crank, hoping that the average development would be about right.

Every few years we get alarmed at our results, and then like a pendulum we swing from one extreme in educational methods and curricula to another. It is time to understand that there is no universal method of education applicable to a large group of men, and that the problem is to keep on analyzing each student during his course and giving him such stimuli as he may need. This, of course, presupposes that we are clear in our minds as to our final product desired, and this is the broadest problem that we educators are called upon to consider and to solve. And there is again a danger there in settling upon just one solution; it is well to remember that it takes all kinds of people to make up this world.

THE UNCONSCIOUS PLAGIARIST.

BY G. I. MITCHELL,

Assistant Professor of Mechanical Engineering, University of Pittsburgh.

The honor of the technical profession is always high, the technical man guards his statements with jealous care and is generally careful to acknowledge the source of any idea not his own. But what are we to think of the authors of technical books who permit matter to appear in their pages that has been taken from copyright material already in existence?

Take the case of the college professor who, let us say, is the head of the mechanical department and is teaching machine design. Not being satisfied with the machine-design texts already in existence, perhaps because the order in which the work is arranged does not agree with his opinions of the subject or because the various relations developed do not meet with his approval, he gets together a set of notes, has them mimeographed and hands a set to each of his students.

Because these notes have been arranged according to the professor's particular notions he finds that they just suit his fancy, he can teach the subject with less friction and with less effort on his part—he does not have to correlate his ideas with those of another. He soon comes to be a firm believer in the fact that he has hit upon an ideal method of teaching his subject and condescends to have his notes published as a text-book that others may have the benefit of his broad intelligence.

Very good. He has been actuated by the best motives. But let us see how these wonderful notes have been collected. Did he sit down at his desk and evolve them from his own mind? The chances are very few that he did. No, he consulted every published text that he could get his hands on and picked out the parts that best suited his own ideas, one part

from one author and another part from a second, and so on. Page after page of his notes was copied verbatim from other men's books, the professor merely running in a few words here and there to avoid a too abrupt change from one authority to another. Since he was simply compiling these notes for his own use, he was not careful to give reference to the men who were responsible for the subject matter.

After the elapse of a few years the professor has forgotten just who he consulted, has forgotten just how he got these notes together, so that when he makes up his mind to publish his text he simply bundles the pages together and sends them off to his publisher. When the book appears it is submitted to the public as a "new and better" text in machine design. It finds its way into schools, the men from whom the author cribbed various parts read the new text and are somewhat surprised to find page after page of their own material. Letters begin to pour into the office of the publisher, causing the publisher much discomfort. But what can the publisher do? He has printed the text in good faith, depending upon the integrity of the author to prevent unpleasantnesses of this nature, but the publisher is more or less responsible, and to say the least, is in a bad position. The author himself loses caste and is regarded as a thief by his brothers.

The remedy is easy to find. Let every author of a book of this kind search his notes with care and wherever questionable material is found, let full credit be given or let him give the old material new treatment so that it will appear in his new book in the author's own words. If the book is worth while it is certainly of the utmost importance that the writer keep his escutcheon clean, with his name placed high in brilliant letters on the roll of his profession.

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EDITORIAL.

A questionnaire was recently sent out by the editor of a technical journal devoted to a highly specialized subdivision of one branch of engineering asking among other questions if it were thought wise to have a chair devoted to that particular subdivision in certain engineering schools. The field of this subdivision is large, the applications are numerous and the chances for further developments are excellent.

Should a chair be established? This at once brings up the question: What is the aim of engineering education? Of education? The question is an old one and in these days of specialists we sometimes forget the way over which we have come to our present position. We begin to think that we should train specialists so that the graduate may start at once to produce in his chosen field of endeavor. We forget that production is the result but not the aim of education. The aim of education is to produce a man who can think straight, who can analyze problems correctly so that a solution may be obtained and who has confidence in himself and his results. To do this there must be a thorough training in fundamentals and these must be emphasized even if no time can be given to the specialists.

In addition to the above point, the highly special branches are unwise because many students do not and cannot know what particular subdivision they are to enter upon on graduation. Many have prepared for one line of endeavor only to find it necessary, on account of changes in condition, to follow another. Because of death or business changes some who have depended on relatives or friends for a definite position on graduation have found it necessary to take up work for which their preparation has not been as complete as it should be.

Our plea is that education should be so thorough in the elements of our profession that the graduate is prepared by little extra study alone to enter any special field of work. The man who can reason from a thorough grounding in mathematics, physics, chemistry and their developments, and in social sciences; who can read what others say in one or two foreign languages; who can express himself clearly and forcefully in his own language and by drawings need not fear to enter any branch of engineering.

Our endeavor in arranging new curricula should be to give a thorough grounding in fundamentals rather than to include the many specialized divisions of engineering.

ARTHUR M. GREENE, JR.

COLLEGE NOTES.

The Kansas State Agricultural College on September 29, 1919, had an enrollment of 500 students in its collegiate engineering courses.

Construction was started on September 24, 1919, on an addition to the Engineering Building which will cost about $200,000, and will provide additional facilities for housing the departments of electrical engineering and civil engineering.

Missouri School of Mines.—The Missouri School of Mines has just issued a bulletin on "A Bibliography on the Roasting, Leaching, Smelting and Electrometallurgy of Zinc." This is a book of about 400 pages and can be had free of charge by those interested in zinc metallurgy.

The following special lectures were delivered before the Missouri School of Mines students in October:

"Treatment of Refractory Ores by the Wet and Dry Chlorination Methods," by F. G. Moses, hydrometallurgist, U. S. Bureau of Mines, Salt Lake City.

"Electrolytic Zinc," by Earl S. Bardwell, superintendent ferro-manganese department, Anaconda Copper and Mining Co., Great Falls, Mont.

"Electrolytic Copper Refining," by Earl S. Bardwell, superintendent ferro-manganese department, Anaconda Copper and Mining Co., Great Falls, Mont.

"The Use of Air Lift Pump on Tailings Disposal at Hurley, New Mexico," by H. T. Abrams, manager, Air Lift Department, Ingersoll-Rand Co., New York City.

THE NATIONAL COMMITTEE ON MATHEMATICAL REQUIREMENTS.

The National Committee on Mathematical Requirements was organized in the late summer of 1916 for the purpose of giving national expression to the movement for reform in the teaching of mathematics which had gained considerable headway in various parts of the country.

The membership of the committee at present is as follows:

Representing the colleges:

A. R. Crathorne, University of Illinois,
C. N. Moore, University of Cincinnati,
E. H. Moore, University of Chicago,
D. E. Smith, Columbia University,
H. W. Tyler, Massachusetts Institute of Technology,
J. W. Young, Dartmouth College (chairman).

Representing the secondary schools:

Vevia Blair, Horace Mann School, New York (representing the Association of Teachers of Mathematics in the Middle States and Maryland),

W. F. Downey, English High School, Boston (representing the Association of Teachers of Mathematics in New England),

J. A. Foberg, Crane Technical High School, Chicago (vice-chairman) (representing the Central Association of Science and Mathematics Teachers),

A. C. Olney, Commissioner of Secondary Education, Sacramento, California,

Raleigh Schorling, The Lincoln School, New York,

P. H. Underwood, Ball High School, Galveston, Texas,

Eula Weeks, Cleveland High School, St. Louis, Mo.

Last May the committee was fortunate in securing an appropriation of $16,000 from the General Education Board, which has made it possible greatly to extend its work. This

work is being planned on a large scale for the purpose of organizing a nation-wide discussion of the problems of reorganizing the courses in mathematics in secondary schools and colleges and of improving the teaching of mathematics.

J. W. Young and J. A. Foberg have been selected by the committee to devote their whole time to this work during the coming year. To this end they have been granted leaves of absence by their respective institutions.

The following work is being undertaken immediately:

1. To make a careful study of all that has been said and done here and abroad in the way of improving the teaching of mathematics during recent years.

2. To prepare a bibliography of recent literature on the subject.

3. To make a collection of recent textbooks on secondary school and elementary college mathematics.

4. To prepare reports on various phases of the problem of reform. Eleven such reports are already under way and others are being projected.

5. To establish contact with existing organizations of teachers with the purpose of organizing a nation-wide study and discussion of the committee's problem. The committee hopes to induce such organizations to adopt this problem as their program for the year. It is ready to furnish material for programs and also to furnish speakers at meetings. The organizations in their turn are to furnish the committee with the results of their discussions and any action taken. In this way it is hoped that the committee can act as a clearing house for ideas and projects and can be of assistance in coördinating possible divergent views entertained by different organizations.

6. To promote the formation of new organizations of teachers where such organizations are needed and do not exist at the present time. These organizations may be sectional, covering a considerable area, or they may consist merely of local clubs which can meet at frequent intervals for the discussion

and study of the problems of the committee. It is hoped that such clubs can be organized in all the larger cities where they do not already exist.

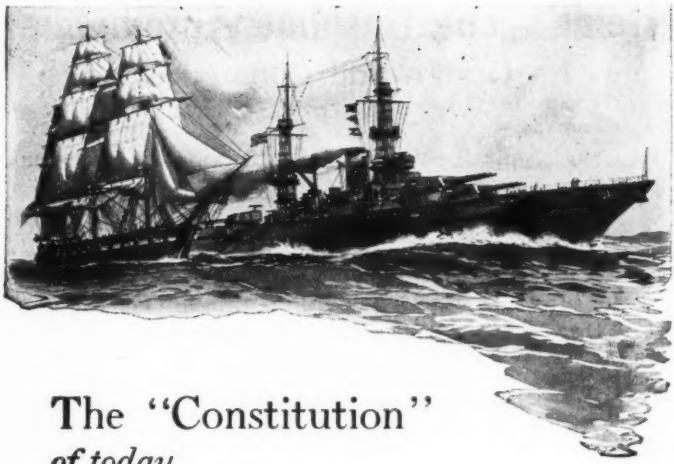
7. To establish contact directly with individual teachers. The committee feels that this is necessary in addition to their work through organizations in order to induce such individuals to become active and in order to make the work through organizations effective. Plans for establishing this contact with individuals on a large scale are under consideration, possibly through the publication of a Bulletin. These plans, however, are as yet in a tentative stage.

Organizations can be of assistance by sending to the committee a statement of the name of the organization, its officers for the coming year, the time and place of its meetings and information regarding proposed programs. If any organization has within the last ten years issued any reports on topics connected with the work of the committee, copies of such reports should, if available, be sent both to Mr. Young and Mr. Foberg. If this is impossible, a statement regarding the character and place of publication of any such reports would be welcome.

Individuals can be of assistance:

1. By keeping the committee informed of matters of interest that come to their notice;
2. By suggesting ways in which the committee can be helpful;
3. By sending to the committee in duplicate reprints of any articles they publish on subjects connected with the committee's work;
4. By furthering the work of the committee among their colleagues, organizing discussions, etc.

It is not too much to say that the existence of this committee with its present resources gives the teachers of mathematics, both individually and through their organizations a unique opportunity to do really constructive work of the highest importance in the direction of reform. They can surely be counted on to make the most of this opportunity.



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